CONF-910403--6

FEB 08 1991

LA-UR -91-362

Los Alamos National Laboratory is operated by the University of California for the United States Department of Energy under contract W-7405 ENG-36

LA-UR--91-362

DE91 007485

TITLE: BATTLEFIELD LASER WAVEMETER

AUTHOR(S): Craig Jensen, CLS-6/J564

SUBMITTED TO: Proceedings of the International Conference on Lasers '90
Society for Optical and Quantum Electronics
McLean, VA

Los Alamos Los Alamos National Laboratory
Los Alamos, New Mexico 87545

DISCLAIMER

MASTER

BATTLEFIELD LASER WAVEMETER

Chris Reiser
Cymer Laser Technologies, Inc.
7887 Dunbrook Road
San Diego, CA 92126

Craig C. Jensen
MS-J564
Los Alamos National Laboratory
Los Alamos, NM 87544

Abstract

In this paper we present a summary of the specifications and architecture for a ruggedized laser wavemeter. This wavemeter is about the size of a pocket calculator and has a wavelength resolution of one part per million. The detectable wavelength range is from the near infrared to the near ultraviolet. The wavemeter is specifically designed to distinguish laser threats from incoherent light sources and measure multiple wavelengths simultaneously. The information update rate is greater than ten readings per second.

Introduction

Lasers play an important role in land, sea and air battle engagements. Lasers are able to disrupt or damage optical sensors used in weapons systems and impair vision of personnel. Lasers can also be used to disrupt sensors and cameras on satellites and eventually to disrupt communications. Currently substantial effort is being devoted to develop countermeasures to the variety of near term and long term laser threats to military assets. One countermeasure technology which has not been adequately developed is laser wavelength measurement. We propose an inexpensive wavemeter which will measure the wavelength of a laser threat with an update rate of more than ten readings per second. The wavemeter will distinguish laser radiation from thermal or explosive radiators and measure multiple laser wavelengths to an accuracy of 1 ppm. The minimum required accuracy for identifying laser threats is 2000 ppm. The wavemeter will operate with equal ability in detecting continuous wave or pulsed lasers.

Design

Computer models were developed to model and design a commercial vacuum Fizeau wavemeter (Lasertechnics, Inc.). This computer model was adapted to develop an all solid state compact wavemeter based on a Girard interferometer (GI). The resulting sensor system has several desirable characteristics:

- 1 ppm wavelength resolution
- all solid construction
- low weight and volume - optics comprise < 1 cm^3
- total size comparable to a pocket calculator
- wide wavelength range limited only by detector response
- measurement readout in real time
- update rate > 10 Hz
- immunity to panchromatic glints
- low false alarm rate
- permanent calibration
- field deployable packaging
- rugged and inexpensive
- simple and reliable
- operation requires no attention from user

There are only three basic elements to the GI based wavemeter sensor: The Girard interferometer, a linear photodetector array and processing electronics. The photodetector array can be bonded directly to the GI to form a single assembly. This assembly can be mounted directly on the electronics circuit board to form a sturdy wavemeter instrument package.

The GI is a cube roughly 1 cm per edge. It is made of two prisms which are glued together at their hypotenuses, that have been partially silvered to act as a beamsplitter. In this configuration it forms a Michelson interferometer, as shown in Figure 1, but with an important modification: The reflector in one arm of the GI is slightly tilted instead of being at exactly 90 degrees to the beam path. Then light enters the GI, half of the light reflects from the normal arm of the interferometer and the other half from the tilted arm. When the two beams combine at the GI output, they produce a sinusoidal fringe at the output face of the GI. The period of the fringe pattern is proportional to the laser wavelength hitting the GI.

Since the photodetector array has been placed at the GI output face, its output appears to be a histogram-like representation of the sinusoidal fringe from the GI. The detector outputs are typically digitized in real time and fed to a computer or signal processor that extracts the fringe period from the data. This function is fairly simple and could also be accomplished with analogue circuitry. The electronics then display the wavelength reading or bus the information to a data recorder. The information in the data recorder can be saved for intelligence on the current threat or used to activate countermeasures.

Application

A laser warning system (LWS) which will be found on any military platform will have three basic components. The first is the collection optic which intercepts a portion of the threatening laser radiation. The collection optic will be different among various platforms such as satellites, aircraft and tanks. In some cases the direction from which the laser threat arrived must be accurately determined and in other cases that information is unnecessary. The second part of the laser warning system is the wavelength determination equipment. The wavemeter described above is the most accurate and compact design yet proposed. The wavemeter also provides the very important advantage of making the wavelength measuring component of the LWS interchangeable among all systems on any platform. Although logistically this is of relatively little importance, the economy of scale provided by using the same wavemeter in all LWS's on all platforms is a tremendous advantage. The third component of the LWS is the data recorder. The data recorder will vary as much among LWS's as the collection optic. The immediate use for the data determines the type of data recorder a particular LWS will have. In some cases the data will be used to analyze the current laser threat to update the data base in the intelligence services. In other cases the data recorder will promptly activate countermeasures for the laser wavelengths measured.

Conclusions

The results of design studies on a compact high resolution wavemeter have been presented. The wavemeter design is especially well suited for the physical and optical demands presented to the military by current and future laser threats. The wavemeter is about the size of a pocket calculator. The small size and low weight of the wavemeter make it suitable for use in space, air, sea and land platforms as well as on individual personnel. The wavemeters operation is independent of the optics which gather the laser threat. The wavelength and pulsewidth information of the laser threat can be displayed for visual observation or remain digitally encoded for specific tasks. The wavemeter is insensitive to the input and output requirements of an overall laser warning system. As such, the same wavemeter can be the heart of all laser warning systems on any platform which in itself provides a tremendous economy of scale.

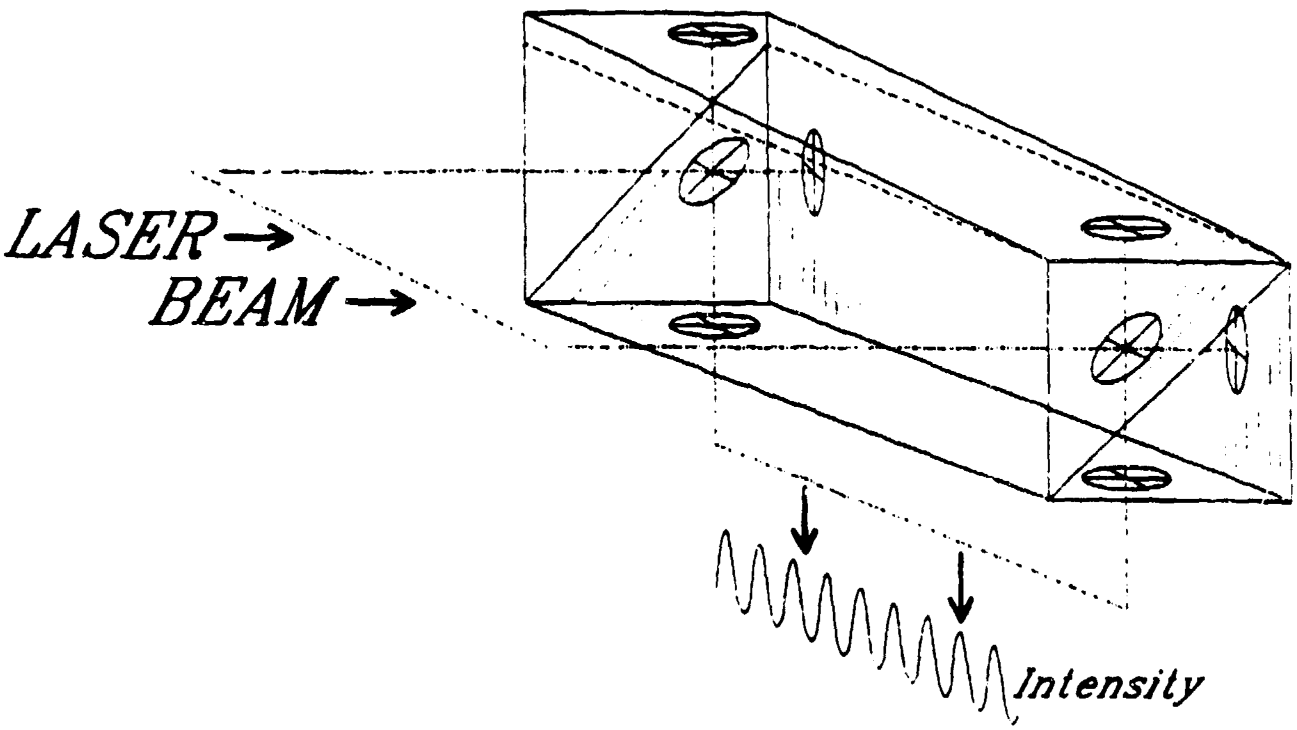

Fig. 1. (Above) The Girard Interferometer (GI) is a solid Michelson-type interferometer with the top reflector tilted at a small angle. This produces a sinusoidal fringe pattern at the GI output. (Below) A complete GI-based sensor would contain a GI, a photodetector array, and electronics in one small package.